

# **Status of EUVL Activities at Taiwan**

**Yang-Tung Huang**

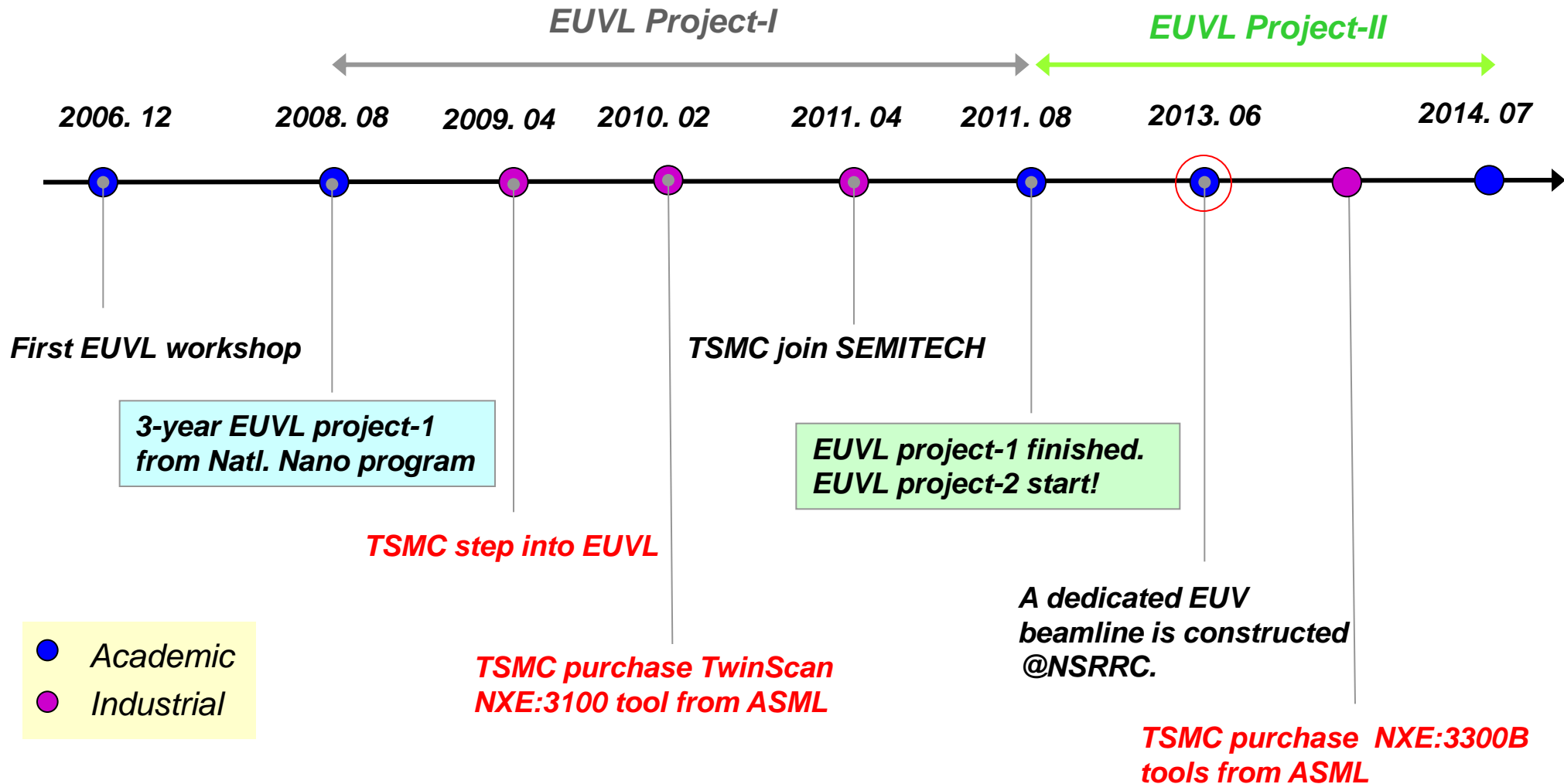
**Department of Electronics Engineering, National Chiao-Tung University (NCTU), Taiwan**

**Bryan Bor-Yuan Shew**

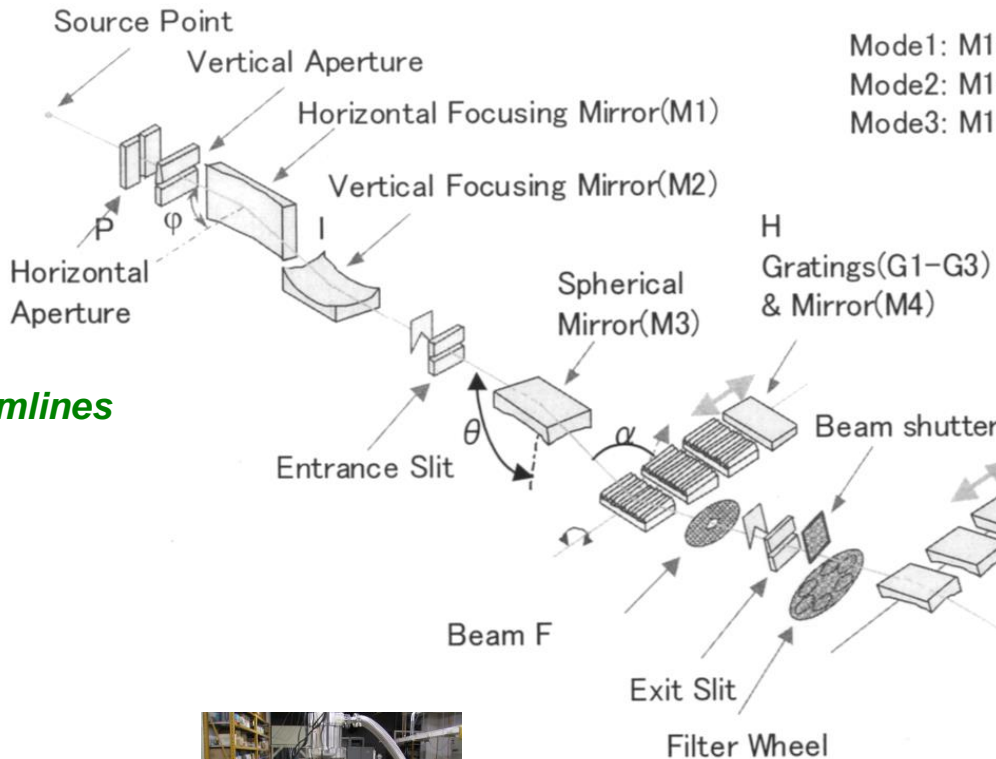
**National Synchrotron Radiation Research Center (NSRRC), Taiwan**

**6/13/2013, Maui, Hawaii**

# Timeline of EUVL Development @ Taiwan



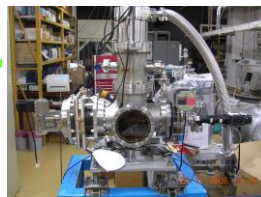
# Review of EUVL Phase-I Project (2008-2011)



**NSRRC beamlines**  
08A1 LSGM  
21B2 U9-CGM

- Initiated the EUVL research at Taiwan
- Several major endstations and technologies were established.
- More than 20 papers were published.
- More than 30 professors and graduate students have joined this EUVL project.
- Joint-development projects with industries (TSMC, ASML, Nissan chemical) were executed.

**This project!!**

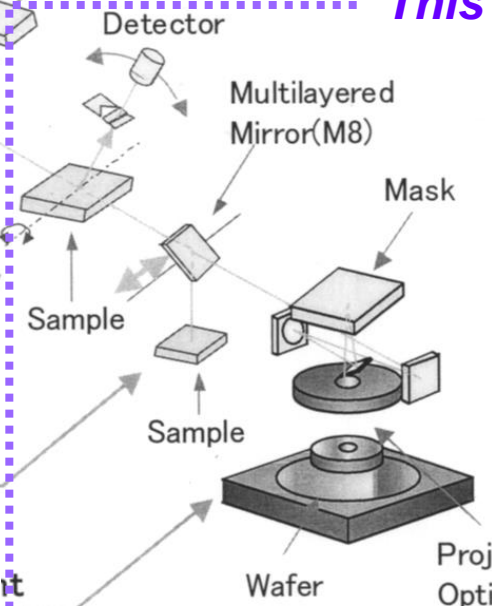


**Reflectometer**

**Resist evaluation system**



**EUV interferometer**



**Device evaluation system**



# Investigations on extreme ultraviolet lithography (EUVL) II

## *- from light source, metrology, to reliability of nano devices*

Principal Investigator: Yang-Tung Huang

Department of Electronics Engineering, National Chiao-Tung University (NCTU)

### **Light Source**

- *Bryan Bor-Yuan Shew (National Synchrotron Radiation Research Center, NSRRC)*
- *Hok-Sum Fung (National Synchrotron Radiation Research Center, NSRRC)*

### **EUV Applications**

- *Bing-Yue Tsui (Dept. of Electronics Eng., National Chiao Tung University)*
- *Chee-Wee Liu (Dept. of Electrical Eng., National Taiwan University)*
- *Shih-Hon Chen (National Nano Device Laboratory, NDL)*

### **Metrology**

- *Yang-Tung Huang (Dept. of Electronics Eng., National Chiao Tung University)*
- *Grace H. Ho (Dept. of Applied Chemistry, National University of Kaohsiung)*
- *Kuen-Yu Tsai (Dept. of Electrical Eng., National Taiwan University)*
- *Jia-Han Li (Dept. of Eng. Science and Ocean Eng., National Taiwan University)*
- *Chun-Hung Lin (Institute of Electro-Optical Science and Eng., National Cheng-Kung University)*
- *Chien-Nan Hsiao (National Instrument Technology Research Center, ITRC)*

(4 Researchers from 3 National Labs and 7 Profs from 4 National Universities  
+ 7 Ph. D & 22 Master students)

# Investigations on extreme ultraviolet lithography (EUVL) II

*- from light source, metrology, to reliability of nano devices*

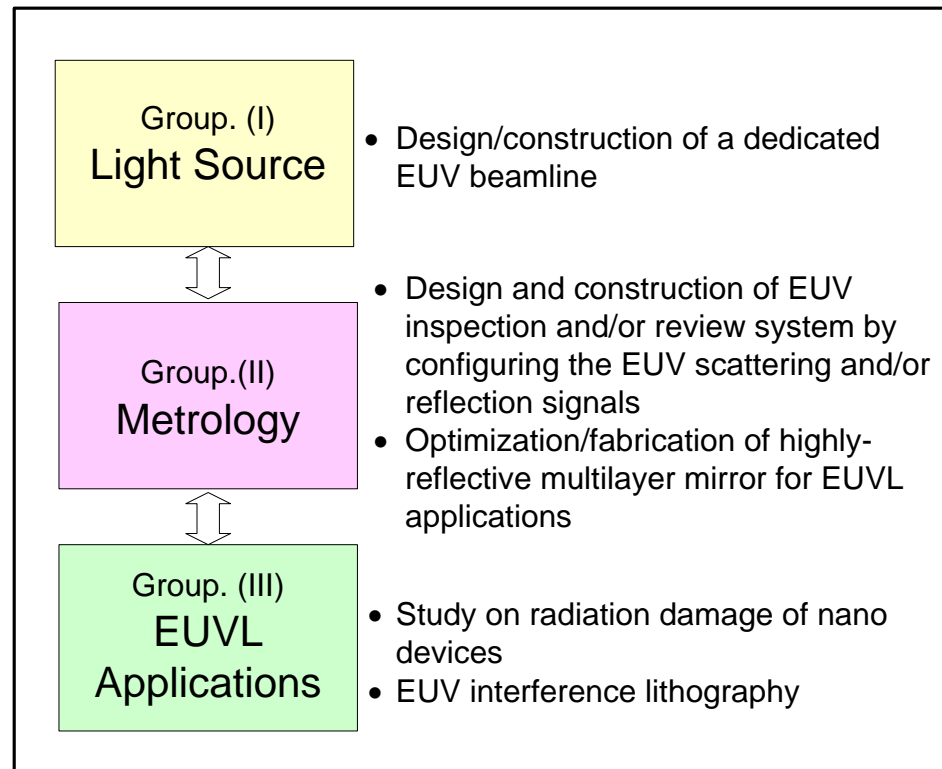
## Natl. Labs Matching

NSRRC  
- SR EUV beamtime

NDL  
- Nano chip fabrication

ITRC  
- Optical coating

## EUVL Project (II)



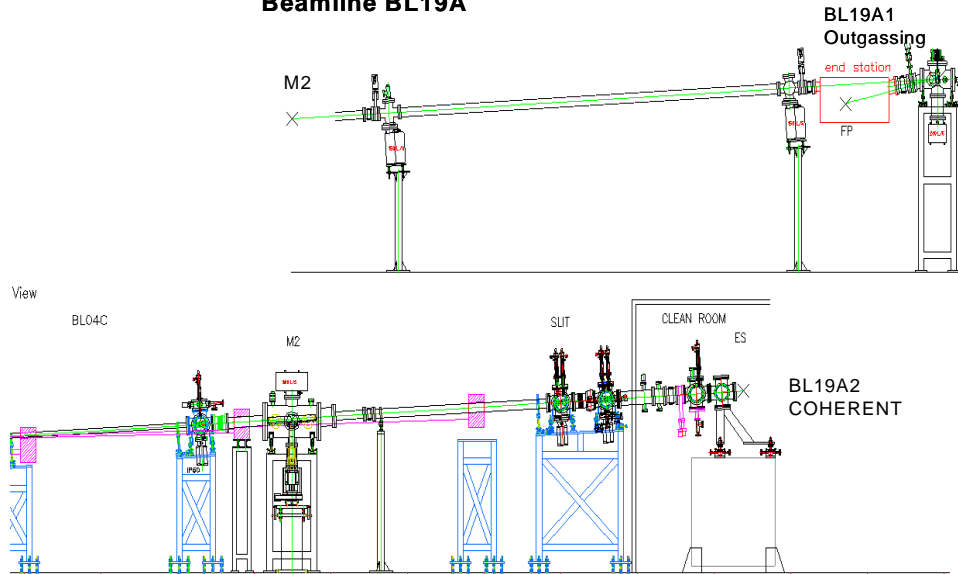
## Major Impacts

- Establish the EUVL core facilities and technologies to meet the R&D requirements both from academics and industrials.
- Integrate and accumulate the talents with various expertise for EUV-related researches

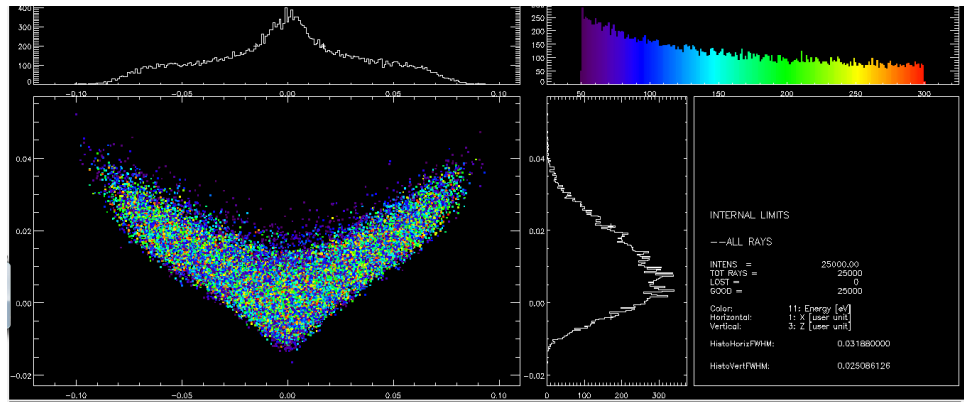
# Status Highlight (1)

## - Construction of a new EUV Beamline

Beamline BL19A



• mechanical drawing



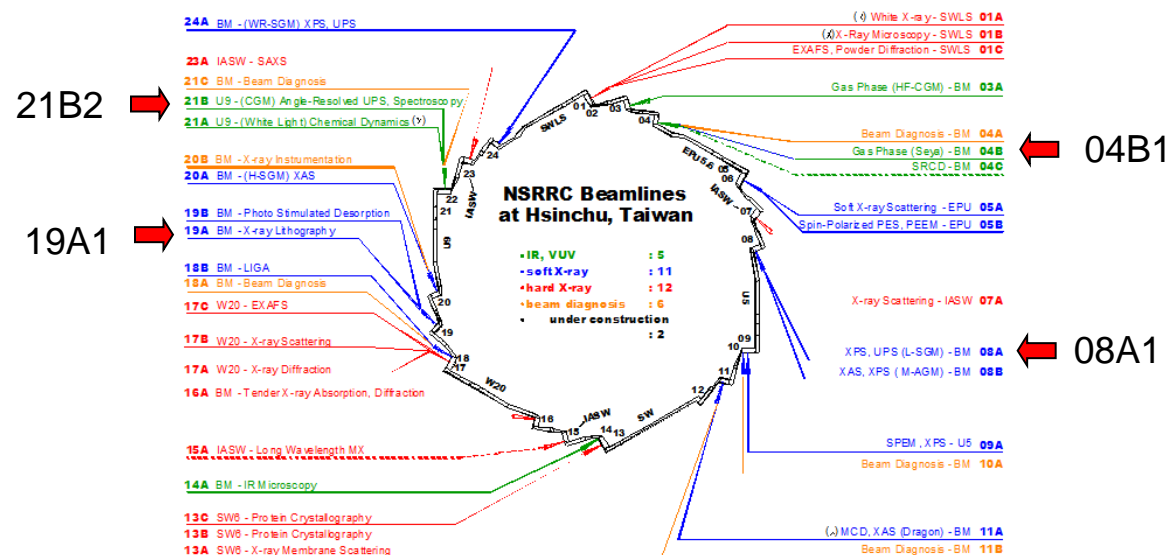
• optical simulation

- Sponsored by NCTU/NSRRC.
- The beamline can be operated in two modes:  
*Coherent mode* for EUV inspection study  
*High-flux mode* for outgassing study.
- The optical design/simulation has been done after four revisions for both *EUUV/BEUV* research.
- The EUV beamline is now under construction. It will be done before *July, 2013*.



# Available Beamlines for EUV Research @NSRRC

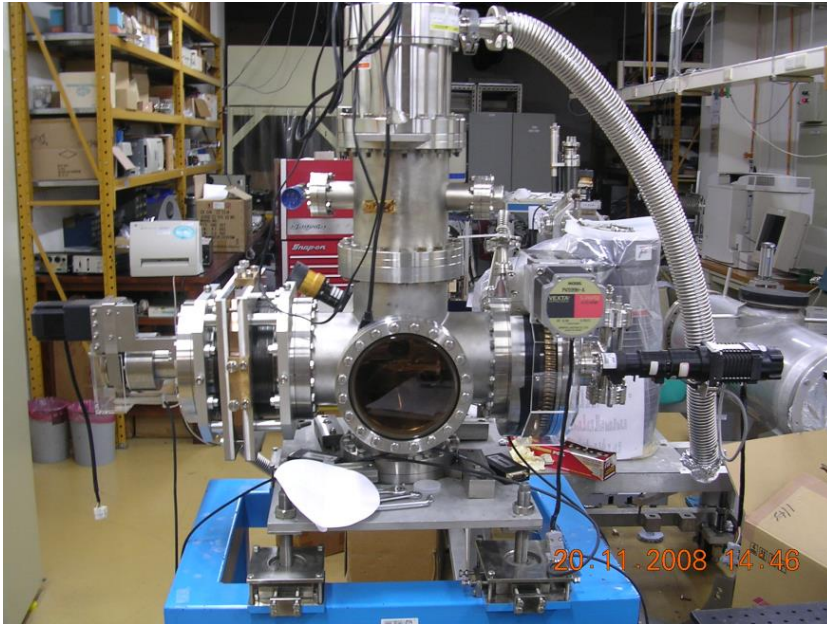
BL No.	BL name	Characteristic	Research topics
19A1	EUV Lithography (new)	● High flux	Outgassing EUV inspection
04B1	Seya	● Lower energy	Out of band measurement
08A1	Photoelectron spectroscopy	● High resolution	Reflectivity measurement Outgassing
21B2	Gas Phase	● High flux/coherence	Interference lithography



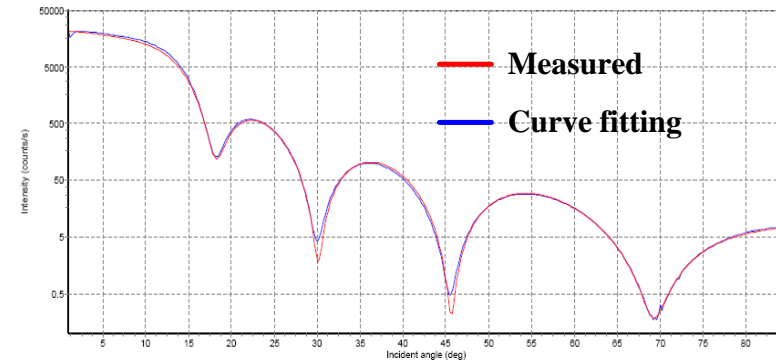


# Status Highlight (2)

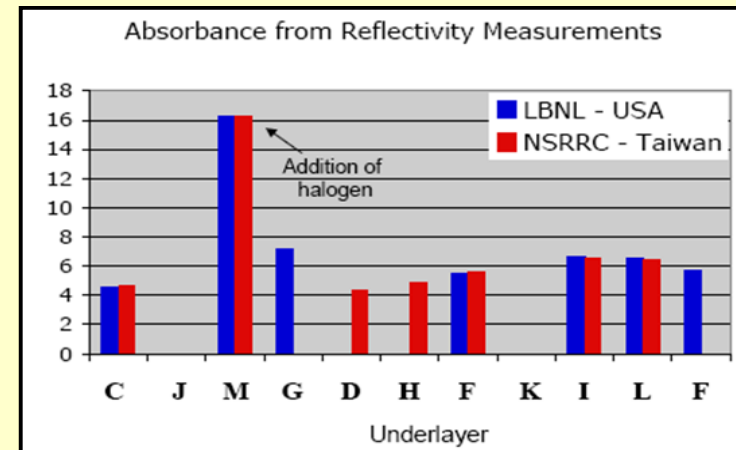
## - Establish a nkt measurement platform @EUV



### • Measurement and curve fitting



### • Bench marking with international facilities.



Polarization geometry	S-polarized
Base pressure	$1 \times 10^{-7}$ torr
Angle of incidence	$0^{\circ} - 85^{\circ}$
Rotation $\theta$ (sample stage)	$360^{\circ}/0.001^{\circ}$
Linear $z$	50 mm
Rotation $2\theta$ (detector stage)	$360^{\circ}/0.0036^{\circ}$



# **Status Highlight (3)**

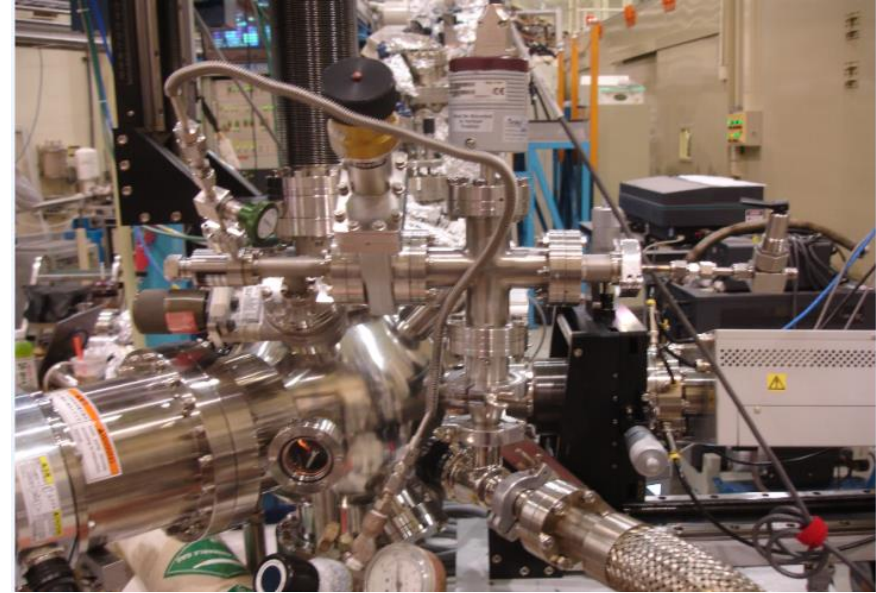
## **- construct a resist outgassing evaluation system with QMS**

**(1) Construction of an outgassing evaluation system.**

**(2) SOP for absolute measurements.**

**(3) Join development projects with TSMC, Nissan Chemical Industries, Ltd., Japan.**

**(4). The Results were presented by Prof. Grace Ho on Wed. (6/12) in this conference.**



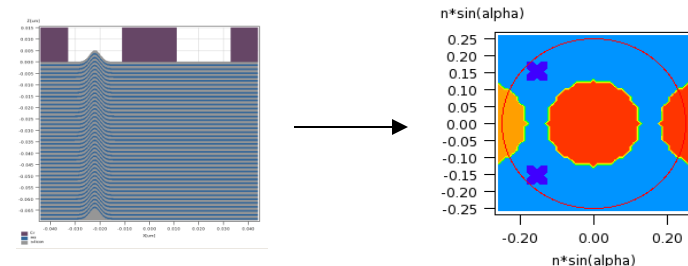
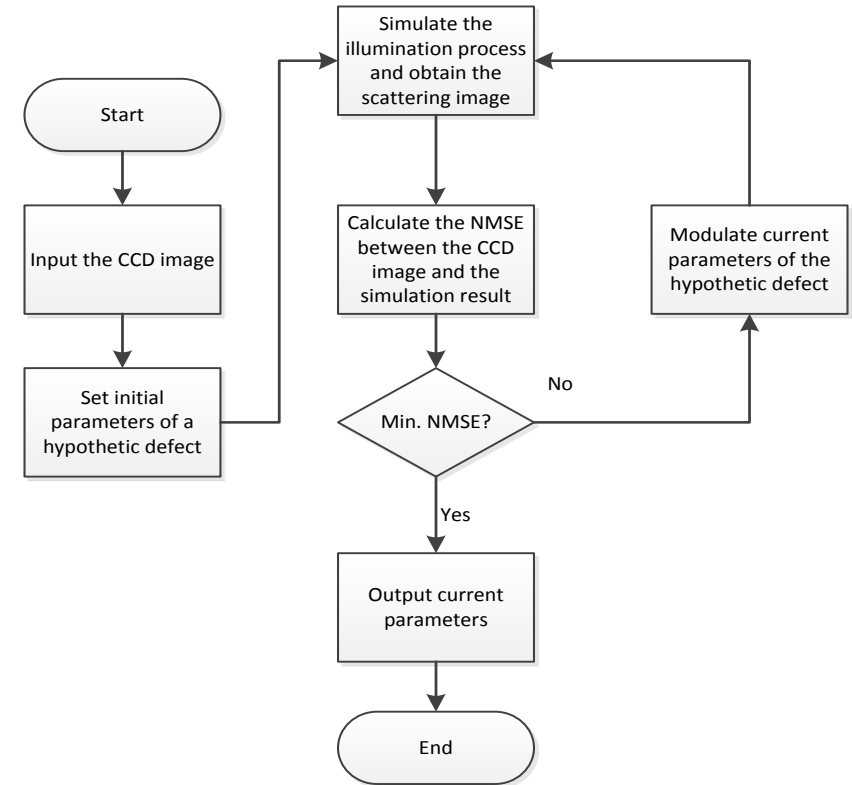
- The chamber is equipped with:
  - (1) **QMS** (quadruple mass spectrometer) for the resist outgassing study.
  - (2) **Double-ion chamber** for precise photon-flux measurement.
- The system can Identify outgassed ion species **directly** and **quantitatively**.

# Status Highlight (4) :

## - New Inspection Method of EUV Mask Defect

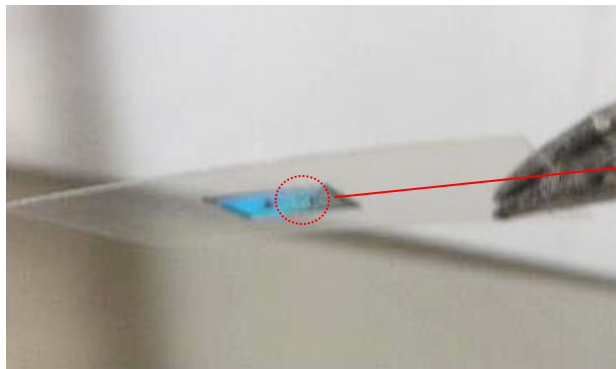
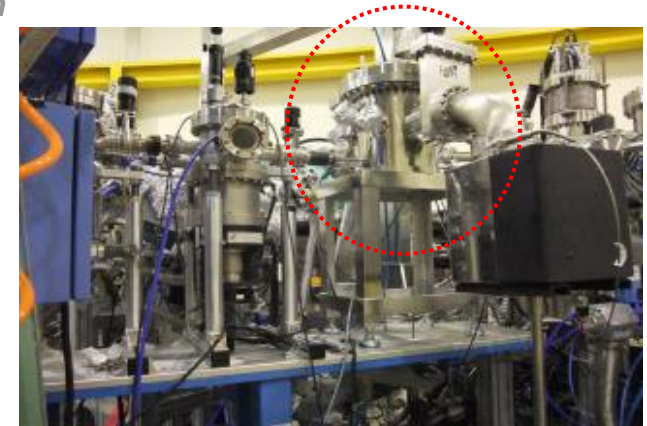
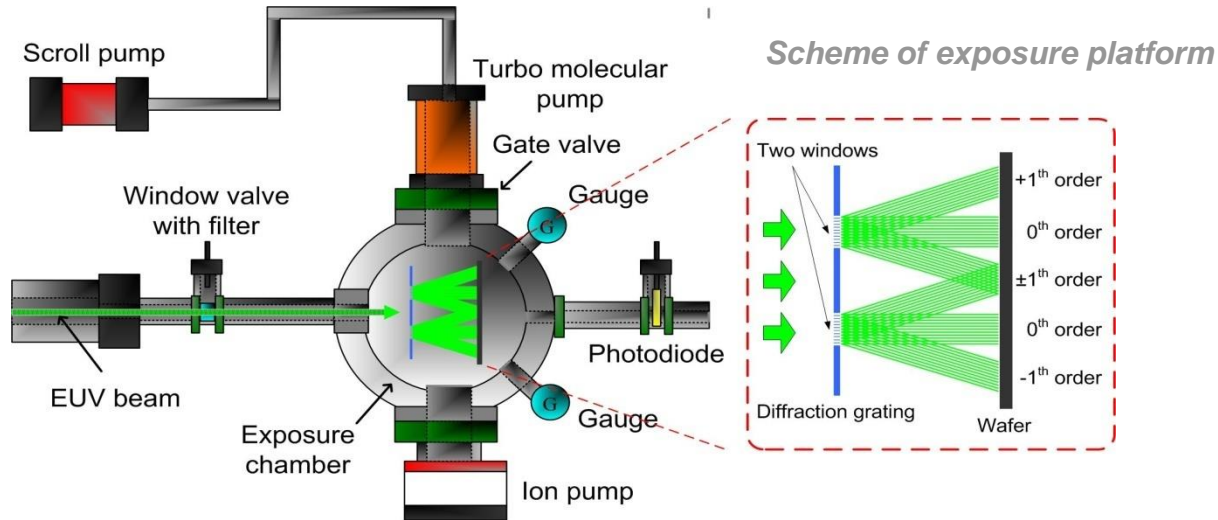
- **Mask defect will cause severe influence on resist profile at nanometer scale.**
- **Applying the new method on defects with decreasing sizes referring to ITRS requirements of 2015, 2018, 2021.**
- **Advantage: significant reduction of calculation iteration, and the new inspection method is fairly reliable if there is no noise.**

Case	FWHM x/nm	FWHM y/nm	Height /nm	Iteration	Number of function evaluations	CPU Time/hr
2015 ("22 nm" node)	9.5615 9.9942	9.5615 9.9958	3.2161 3.0029	106 16	--- 168	1.72 0.7
2018 ("16 nm" node)	7.4728 7.0072	7.4730 7.0134	1.8250 1.9954	279 14	--- 150	4.53 0.625
2021 ("11 nm" node)	3.7969 4.0074	3.7967 4.0081	1.5786 1.4954	225 13	--- 148	3.65 0.617

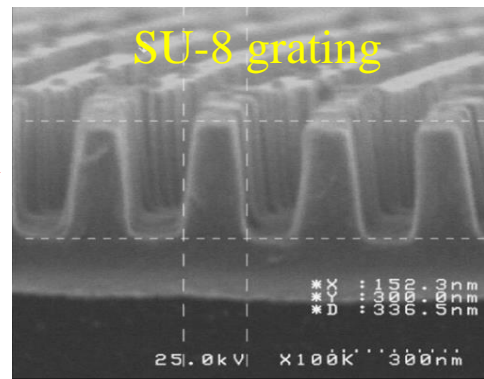


# Status Highlight (5) :

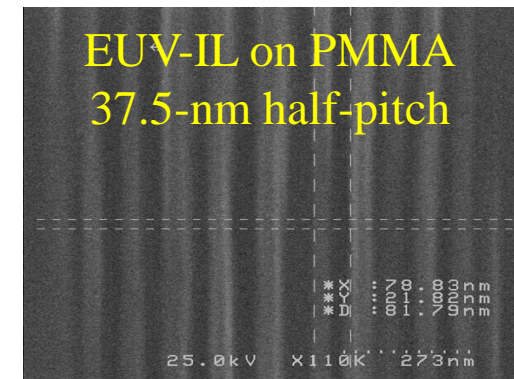
## - Free-standing transmission grating for EUV interference lithography

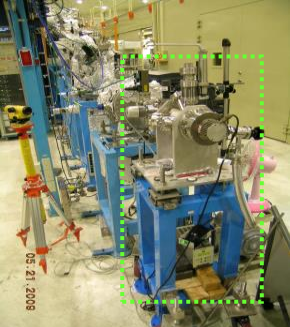


Free-standing SU-8 grating on PET sheet



*EUV IL*

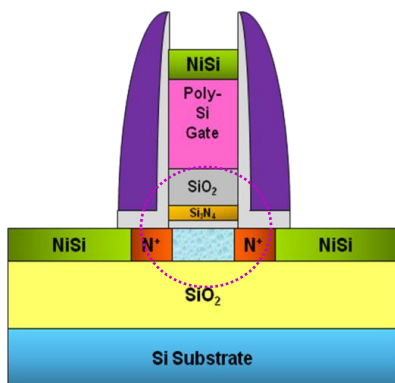




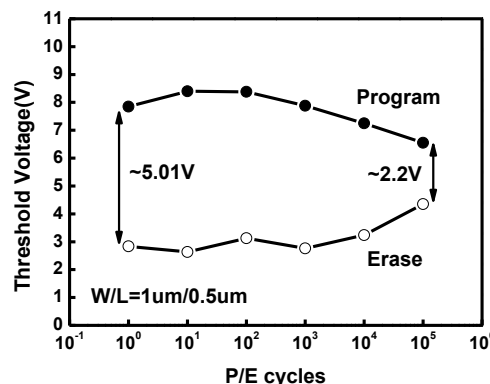
# Status Highlight (6)

## - EUV Irradiation Damages of Nano Devices: Memory Device

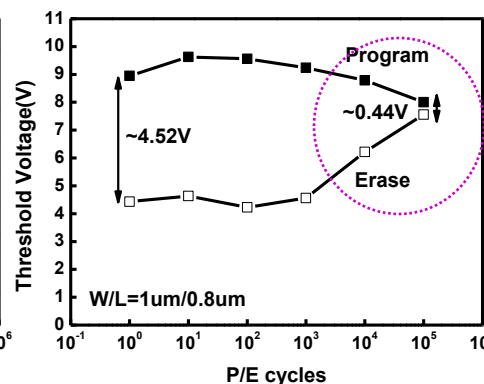
### • SONOS memory



Before EUV Irradiation

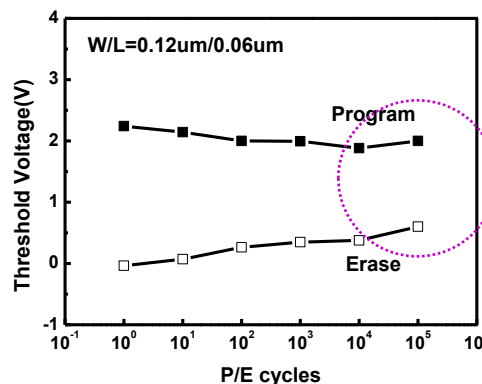
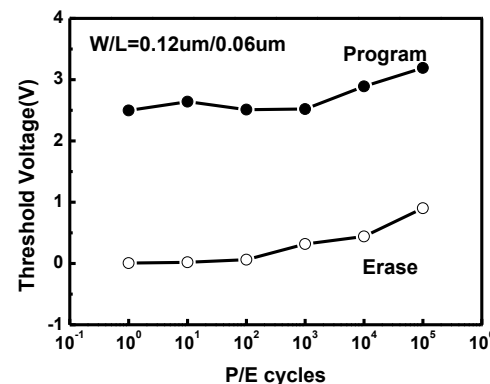
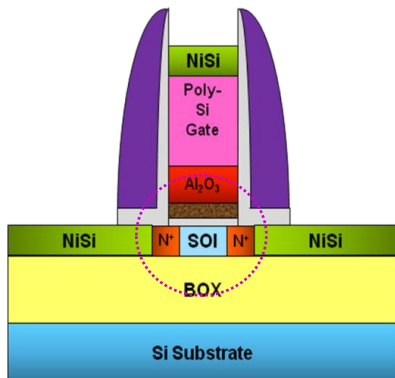


After EUV Irradiation



- EUV irradiation generates net positive charges. New traps are generated in Si<sub>3</sub>N<sub>4</sub>.
- Endurance performance degrades, especially in the erase state due to blocking layer damage.
- Endurance performance can not be recovered by 600°C annealing.

### • NC memory



- EUV irradiation generates net positive charges. In contrast, the charges are trapped in **metallic NCs** but not in traps in dielectric.
- **NC memory exhibits better EUV irradiation damage immunity than the SONOS memory.**

# ***Industrial Application/Cooperation*** **2008-2013**

<b>Type</b>	<b>Title/ Item</b>	<b>PI/Institute</b>	<b>Sponsor</b>
<b>JDP</b>	<i>Outgassing Evaluation for Nissan EUV Underlayer Materials</i>	<i>Grace Ho/NUK</i>	<i>Nissan Chemical</i>
<b>JDP</b>	<i>Quantitative and Qualitative Evaluation of Outgassing from EUV Photoresists</i>	<i>Grace Ho/NUK</i>	<i>tsmc</i>
<b>CP</b>	<i>Simultaneous correction of EUV mask shadowing and proximity effects</i>	<i>KY Tsai, JH Li/NTU</i>	<i>ASML</i>
<b>CS</b>	<i>Lithography study and nkt measurement</i>	<i>BY Shew/ NSRRC</i>	<i>tsmc</i>
<b>JDP</b>	<i>Optical measurement of EUV mask</i>	<i>BY Shew/ NSRRC</i>	<i>tsmc</i>
<b>Collaboration platform</b>	<i>SR Virtual Lab @tsmc</i>	<i>BY Shew/ NSRRC</i>	<i>tsmc</i>

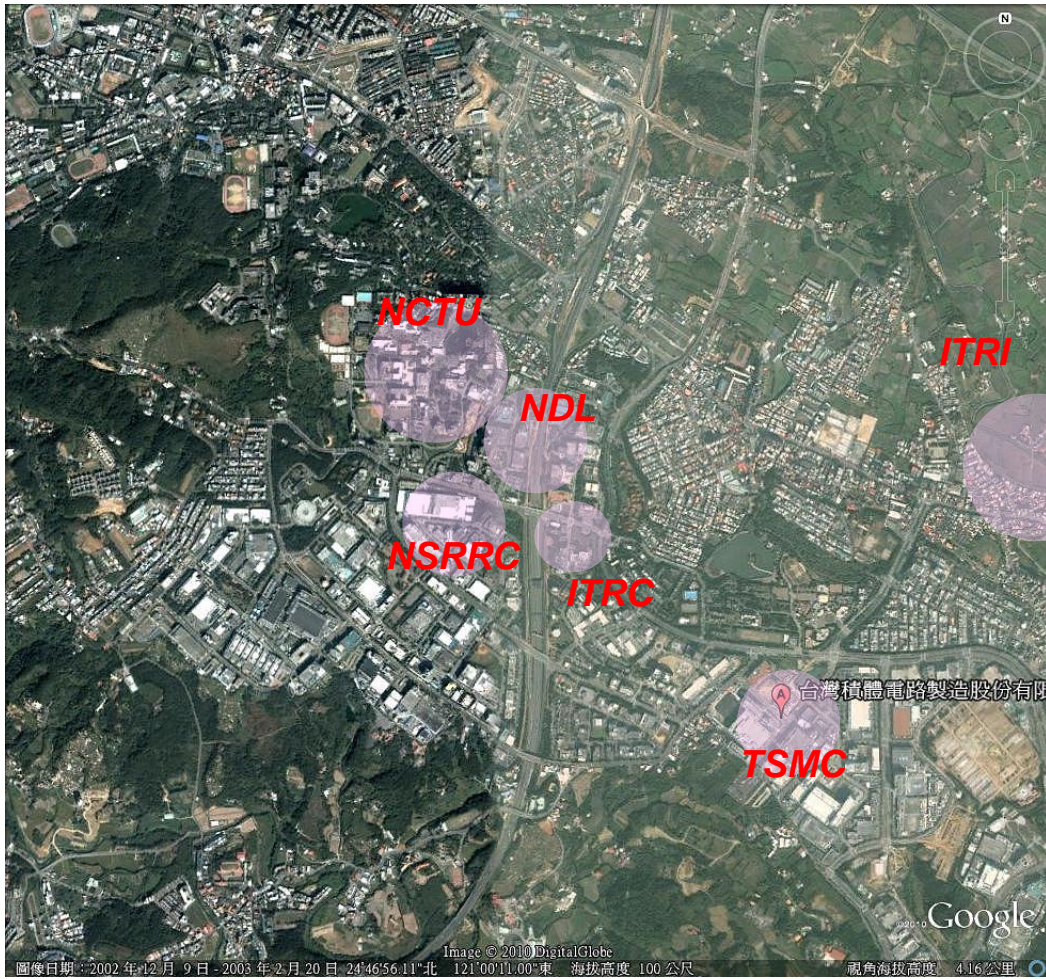
•note:

**JDP**: joint developing project, **CP**: commission projects, **CS**: commission service



# Summary

## ***EUVL Campus@ Taiwan***



- ***The EUVL researches @Taiwan are going on both in academia and industry!!***
- ***Several endstations have been established in NSRRC for EUVL research and analysis!***
- ***An integrated “EUVL campus” has been formed at Hsinchu science park.***
- ***We believe Taiwan will play an important role on EUVL mass production in the near future.***

**3x3 km<sup>2</sup>**



***Thanks for your Attention!***